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ABSTRACT

To provide a compendium of methodologies on cost impacts of automated hospital information systems (AHIS), this report sponsored by the National Center for Services Research identifies, reviews, and summarizes ten studies on information systems which manage patient care data. The studies were identified by a literature search and those that included a description of cost impacts were selected for detailed analysis. Most studies considered labor savings through workload reduction and/or time saved and labor force reduction. The saving of nursing labor was the largest single cost reduction identified. Four different techniques used for estimating workload changes were task analysis, job content analysis, work sampling, and trend analysis. Other methodological issues indicate that turning time savings into labor force reductions requires a deliberate effort to reorganize services and cost, and that benefits must be evaluated and documented in selecting an AHIS. Also, regression analysis can be used to study impacts of AHIS implementation retrospectively. A comparison of three AHIS cost impacts, predictions, conclusions, and recommendations for an approach to AHIS cost evaluation, and directions for future research are included. Nine tables, 11 references, and an extensive list of current National Center for Health Services Research publications are provided. (RBF)

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RESEARCH SUMMARY SERIES

Methods for Evaluating Costs of Automated Hospital Information Systems

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Foreword

The growing interest in the application of computer techniques for institutional and patient care management has spawned a variety of different system approaches. The cost implications of these approaches range from hundreds of thousands of dollars to several million dollars for the individual hospital. It is widely accepted that other than facilities improvement (new construction, additions, major remodeling, etc.), automated data processing represents the largest single capital expenditure facing hospitals in the future.

To use this expensive technology effectively, it is imperative that the hospital community be able to not only project the cost of a proposed system, but also be able to assess potential savings so that the net cost (or savings) resulting from the application of such systems can be estimated. This study provides an overview of the methods available for estimating and measuring the cost impact of automated hospital information systems. It will be obvious to the reader that no standard validated methods are available for predicting the cost impact of this technology. The findings in the report, however, provide the foundation for future research which should ultimately lead to the demonstration and validation of methods which individual hospitals can use with confidence.

Gerald Rosenthal, Ph.D.
Director

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Introduction

Background

Computerization offers the hospital a means of managing an increasing volume of clinical and administrative information. Since computerized hospital information systems were first used in the 1960's, numerous products offering varying scope, functions, and system configurations have been marketed; some hospitals have even developed their own systems. Consequently decisionmakers considering automated information handling are faced with numerous options, each offering different benefits.

Computerized information handling can be very costly. A comprehensive hospital-wide system—one that integrates patient records and reports for all hospital departments—for a moderate size hospital may have a purchase price of several million dollars. A smaller system processing information for one hospital department, though less expensive, will have more limited impacts on hospital operations. Thus, decisionmakers need to consider the costs of the various forms of computerized information handling and weigh these against the benefits of each option.

The cost impacts of Automated Hospital Information Systems (AHIS) are the changes resulting from automation that can be expressed in terms of dollars. These impacts have been examined in several studies. Some have been sponsored by the federal government and others by vendors of commercial systems and individual hospitals. Since no compendium of the methodologies used in these studies was available, the National Center for Health Services Research sponsored a study to identify and review these methodologies and to prepare a report summarizing and critiquing them. This report summarizes the findings of the study.*

* Copies of the complete report of the study are available from the National Technical Information Service. The document number is PB 80-178-593.

Objectives and Scope of the Study

The study had two basic objectives: to evaluate current methods for estimating cost impacts of AHIS and to recommend areas for future research. Existing methodologies for studying cost impacts were assembled, reviewed, and summarized in a format useful to hospital administrators, health planners, and other decisionmakers. These methodologies were analyzed and the usefulness of methodologies from other applications was also considered.

The cost evaluation studies considered involved information systems that managed data used in patient care—those systems dedicated to administrative functions were excluded, as were systems designed primarily for patient diagnosis and treatment (e.g., computed tomography scanners, automated radiotherapy planning systems, etc.).

Approach

AHIS cost evaluation studies were identified by a literature search, which included use of computerized abstracting services; a survey of vendors of systems performing clinical information handling functions; a review of available information concerning applications for Certificates-of-Need; and contacts with researchers in the field. Studies dealing explicitly with cost and cost impacts were reviewed, and those that included a description of an evaluation of cost impacts were selected for detailed analysis. These studies include most of the published work in the field.

Studies concerning AHIS costs and cost impacts

Ten studies represent the current state of the art of assessing cost impacts of AHIS implementation and most of the published work in the field (1–10). The studies are listed in Table 1, which also presents an overview of the purpose and approach of each study.

Basic approaches

Two basic techniques have been used in analyzing the cost impacts of automated hospital information systems. In one method, the costs before system implementation and after system implementation are determined and compared in order to isolate the cost impact of the system. In the other type of methodology, cost impacts are predicted before the system is implemented based on baseline data concerning hospital operations, knowledge of potential system impacts, and the experience of other users. This type of study is actually not a true evaluation in that it is done prospectively in anticipation of the impacts expected in the future. The predictive methods are useful for decisionmakers considering acquiring an automated hospital information system, but the retrospective type of study that examines actual hospital experience is necessary to provide data on actual impacts for use in developing or validating predictive models.

Before and after studies rely on measurements of the process of information handling and on comparison of costs of certain aspects of hospital operations. Since the baseline data required to evaluate impacts are usually not available from hospital records, two periods of data collection are required—one before implementation (to establish the baseline) and one after implementation. Depending upon the scope of the evaluation, this data collection effort can be substantial.

Actual measurement of cost impacts has usually taken place in studies in which the number of impacts is small, the major impacts are easily measured and tied to AHIS functions, and the

Table 1. Overview of AHIS cost studies

Source	Type of AHIS	Institution setting	Purpose of evaluation	Study design	Cost factors/variables
Arenson, R. L. and J. W. London, "Radiology Operations Management Computer System, Hospital of the University of Pennsylvania," in *Proceedings of the American College of Radiology Sixth Conference on Computer Applications in Radiology*. March 1979.	Radiology Operations Management Computer System performing registration and scheduling, file room management, patient tracking, reporting, accounting and statistics	University teaching hospital—radiology department performing 130,000 diagnostic examinations per year	Compare annual costs of automation and annual cost savings achieved. (focused on directly measureable costs and cost savings)	1. Calculate annual costs for system hardware, personnel, supplies, maintenance, and installation. 2. Calculate savings achieved through: • personnel reductions (workload reduced or functions eliminated such as card filing, film library maintenance, and billing office clerk) • recovered billing losses (2.5% lost charges) • reduction in paper costs (forms eliminated) 3. Subtract savings from costs to yield net costs	1. Cost Factors • annual system hardware, software, maintenance and installation over 8-year system lifetime • annual salaries (including benefits) • annual supply costs 2. Revenue recovery, assumed to have face value of lost charges

Barrett, J. P., P. L. Hersch, and R. J. Caswell. *Evaluation of the Implementation of the Technicon Medical Information System at El Camino Hospital. Part II. Economic Trend Analysis.* Battelle, Columbus, Ohio, May 14, 1979.	Technicon Medical Information System—hospital-wide computerized system processing a broad range of medical and administrative data	El Camino Hospital Mountain View, CA: 464-bed general acute care, non-profit, short-term community hospital compared with: • Good Samaritan Hospital, Santa Clara: 315-bed short-term general community hospital • Sequoia Hospital District: 492-bed short-term, general, tax district hospital • Peninsula Hospital and Med. Ctr: 343-bed, short-term, community hospital • Mills Memorial Hospital: 301-bed short-term, general community hospital	Validate internal economic analysis at ECH by a trend analysis among ECH and four other California hospitals	1. Collect monthly hospital cost and service data over six years (1970–1975) 2. Create a uniform data base by aggregation into nursing functions, therapeutic and diagnostic ancillaries, support services, all departments, and total hospital, using direct expenses. 3. Expand sample of observations by use of pooled regression and estimate economic impact of TMIS 4. Compare estimated impact with actual experience at other hospitals	72 variables tested relating to administrative measures (occupancy, case flow rate, personnel mix and turnover, units of service, labor hours per case and per patient-day), patient characteristics (mix by age, reimbursement type, LOS for 10 selected diagnostic categories, surgical procedures), and costs (per case, per day by service, per diem rates, payroll expenses, prevailing wage rates)

Table 1. Overview of AHIS cost studies (continued)

Source	Type of AHIS	Institution setting	Purpose of evaluation	Study design	Cost factors/variables
Brian, E. W., *et al. Cost Benefit Analysis of Installation of a Spectra System at Santa Monica Hospital.* University of Southern California Center for Health Services Research. March 21, 1975, Revised January 1976.	Hospital-wide minicomputer-based system: Spectra 2000	Santa Monica Hospital, a 350-bed acute care community hospital	Determine if computer-based information handling is cost-effective when costs are compared with cost savings in charge capture, forms replacement, and personnel reduction.	1. Determine undercharge error rate in patient billings by random sampling of patient charts and comparison with bills; project total revenue loss. 2. Calculate cost of manual forms to be replaced (could not be compared with costs for computer system supplies). 3. a. Survey departments and select those where personnel changes might be significant. b. By time-motion studies estimate workload reduction from automation. c. Estimate personnel cost savings (labor force reductions) by phasing reductions to be achieved from reduced workload over 5 years (30%, 50%, 66%, 83%, 100% in the respective years). 4. Calculate cost to cost savings ratio for each of first 5 system years.	*Assumptions:* 1. Increased charge capture will result in equivalent increases in hospital revenue. 2. Predicted FTE workload reductions across units/departments and shifts will result in labor force reductions.

Cost-Benefit Analysis of Data-Care System (unpublished). Fairfax Hospital System, Falls Church, VA	DataCare, Inc. hospital-wide computerized system, processing a broad range of medical and administrative data for inpatients and outpatients	Fairfax Hospital	Determine present value of system costs and savings over 8-year life cycle of automated hospital information system.	1. Compute system costs for each year of system life. a. capitalize costs/fees for hardware and software b. phase costs for start-up, upgrading, and internal system support 2. Compute cost savings for each year of system life. a. identify by function analysis, non-nursing jobs to be eliminated and compute payroll savings b. compute savings for forms and current data processing c. compute one-time cash flow benefit for billing office (reduced lag) 3. Compute net benefit for each year. 4. Compute and sum present values (at discount rates of 6%, 9%, and 12%) to yield present value of lifetime net benefit.	1. Present values of annual costs, savings and net benefits.

Table 1. Overview of AHIS cost studies (continued)

Source	Type of AHIS	Institution setting	Purpose of evaluation	Study design	Cost factors/variables
Gall, J. E. *et al. Demonstration and Evaluation of a Total Hospital Information System* National Center for Health Services Research NTIS PB 262 106, 1975.	Technicon Medical Information System—hospital-wide computerized system processing a broad range of medical and administrative data	El Camino Hospital Mountain View, CA: 464-bed general acute care, non-profit, short-term community hospital compared with six similar nearby hospitals.	Evaluation of cost impact of AHIS	1. Predict labor savings by use of Methods Time Measurement Model comparing manual vs. AHIS performance of clerical tasks 2. Compare trends in nursing labor and ancillary labor hours actually expended after 2 years of AHIS with labor hours expected to be expended under the manual method. 3. Compare trends in nursing and ancillary labor at ECH and six similar nearby hospitals during two 18-month hospitals before and after AHIS implementation and predict difference at ECH.	1. Labor hours per month 2. Nursing labor hours per patient-day and ancillary labor hours per admission 3. Nursing labor hours per patient-day and per admission and labor hours per admission for selected ancillaries

Huff, W. S. and E. J. Bond. *Demonstration of a Shared Hospital Information System*. The Sisters of the Third Order of St. Francis, Peoria, IL	Custom-built system for three hospitals with a shared computer facility	Three affiliated hospitals—evaluation carried out at only two sites	Test five independent hypotheses relating to quality, efficiency and cost of patient care by comparing selected operating characteristics before and after system implementation	1. Control other variables by eliminating changes in unit/department location, procedures, staffing, etc. during before and after experimental period. 2. Cost hypothesis: system implementation can be achieved without significantly affecting the cost of patient care • Measure productivity of nursing staff (standard work hours as a percentage of total clock hours for RN, LPN, and trained attendants) and of admitting staff by work sampling • Measure reduction in cost of routine services by labor displacement (standard times and volume samplings) per patient-day in nursing stations and admissions • Measure reduction in cost of radiology and laboratory services by labor displacement	• Percent idle time of total clock hours • hrs saved per patient-day times salary/wage • hrs saved per procedure times salary/wage

Table 1. Overview of AHIS cost studies (continued)

Source	Type of AHIS	Institution setting	Purpose of evaluation	Study design	Cost factors/variables
Kim, S. H. and H. H. Schmitz, "A Cost-Benefit Analysis of a Modular Hospital Information System," in M. W. Hopfe [ed.] *American Institute for Decision Sciences Proceedings*. Boston, MA Nov. 14-16, 1973	(not stated)	(not stated)	Compare actual cost of modular AHIS with present value of total stream of net cash flow (resulting from recovery of lost charges)	1. Obtain revenue increases for first three years from actual financial data; project next 5 years by use of 5% annual increase 2. Obtain additional costs of system for first year, project for next 7 years based on 5% annual increases 3. Compute net cash flow changes (gains in revenue minus additional costs) for each of 8 years of system lifetime 4. Compute present values at 6%, 8%, and 10% discount rates and sum NPV for 8-year system life for each rate 5. Calculate profitability indexes by dividing NPV by cost of AHIS	*Assumptions:* Costs and revenue savings will increase at 5%

Mishelevich, D. J., W. G. Gipe, J. R. Roberts, C. Denny, A. D. Stern and M. W. Day, "Cost Benefit Analysis in a Computer-Based Hospital Information System," in *Proceedings of the Third Annual Symposium on Computer Applications in Medical Care, 1979.*	Radiology department ordering, work management and reporting system developed by Parkland Hospital—Parkland On-Line Information System (POIS)	University Teaching Hospital (Dallas County District Hospital)	Determine total departmental and unit costs with and without the system for a standard patient load	1. By use of industrial engineering techniques and compartmental analysis, derive costs of an hypothetical average procedure • define average procedure • measure direct time and labor for all steps in procedure • measure indirect time and personnel time by work sampling • distribute overhead over transaction volume for standard patient load, adjusting post-implementation volume to reflect avoided duplicate procedures (3%)	1. Annual total cost of producing transaction volume for standard patient load *Assumptions:* 1. Departmental overhead and x-ray equipment costs same before and after 2. Clerical salaries increase due to requirement for data input 3. Physician costs excluded (fee for service) house staff costs included.

Table 1. Overview of AHIS cost studies (continued)

Source	Type of AHIS	Institution setting	Purpose of evaluation	Study design	Cost factors/variables
Schmitz, H. H., "An Evaluation of the Immediate Financial Impact of the Hospital Information System at Deaconess Hospital," p. 265–282 in R. C. Koza [ed.] *Health Information Systems.* Colorado Associated University Press. Boulder, Colorado, 1974.	(not stated)	Deaconess Hospital St. Louis, MO	Determine if any significant changes in revenue and volume indicators for the hospital changed as a result of AHIS	1. Calculate direct expense per patient-day before and after • compute non-room revenue per patient-day • eliminate effect of inflation 2. Calculate number of tests performed per patient day before and after to test for changes other than recovery of "lost" charges 3. Evaluate possible explanations for changes	1. Annual system hardware, software, maintenance and installation over 8-year system lifetime 2. Annual salaries (including benefits) 3. Annual supply c

Technicon. Cost-Benefit Analysis of the Technicon Medical Information System (MIS) For "X" hospital, December 1975.	Hospital-wide	[Methodology may be applied to any setting]	Project savings in labor, forms, equipment over first 5 operational years of TMIS.	1. Calculate labor time savings by job title per unit of work 2. Multiply traffic data (daily volume) times unit savings to yield FTE labor reduction for all but nursing labor. 3. Obtain realizable work force reduction by rounding down for ancillary departments and considering job shifting and other measures for other departments. 4. Calculate labor savings per year based on incremental changes in staffing patterns, attrition, etc. including expected salary increases. 5. Calculate cost avoidance *for nursing labor* by regression based on trends in nursing labor and assume trend to increases will be arrested (based on experience at El Camino). 6. Estimate cost savings for eliminated forms.	1. Minutes per task 2. Minutes per day 3. FTE 5. FTE increase avoided based on nursing hours per patient-day 6. $ per day.

impacts will be realized in a short time (so that the influence of other variables is minimal). Therefore, most of these studies that measured cost savings have been conducted for departmental systems. The study by Arenson and London (3) is an example of this type of approach.

The two studies at El Camino Hospital (1, 2) and the evaluation at the hospitals of the Sisters of the Third Order of St. Francis (6) are examples of attempts to determine impacts of a comprehensive AHIS by measurement and comparison of a wide range of information handling activities and costs before and after system implementation.

Methodologies for predicting the potential cost impacts of automated hospital information systems have been developed to examine both comprehensive hospital information systems and departmental systems. Most of the predictive methods examine the personnel and supplies (mainly paper forms) impacts and compare these with the system costs. Examples of this type of study are the Technicon methodology (10) and the study by Mishelevich *et al.* (8). Most predictive studies consider one-year system costs and cost savings. Three of the studies listed in Table 1 include a multi-year cost analysis: the Technicon methodology (10) includes the first 5 years of system operation and the Fairfax Hospital (5) and Kim and Schmitz (7) studies cover life-cycle (8-year) cost impacts.

Purposes and perspectives

Varied purposes in implementing an AHIS and in undertaking a cost study and varied expectations regarding cost and other impacts are reflected in the ten studies identified. Examination of cost impacts was the focus of studies at Santa Monica Hospital (4), and Fairfax Hospital (5), among others, whereas quality of care benefits (most of which are difficult to express in dollars), as well as cost impacts have been evaluated in the El Camino (2) and the Sisters of the Third Order to St. Francis study (6).

Characteristics of AHIS and settings

Systems for radiology departments are examined in the studies by Arenson and London (3) and Mishelevich *et al.* (8). The other studies included in Table 1 consider hospital-wide automated information handling. In the case of the systems at Santa Monica

Hospital (4) and Deaconess Hospital, St. Louis (7, 9), the system configuration is a modular or distributed one. Commercial systems are involved in the Technicon (10), Fairfax Hospital (5), and Santa Monica Hospital (4) evaluations, whereas the systems studied at El Camino Hospital (1, 2) and the hospitals of Sisters of the Third Order of St. Francis (6) were early versions of systems that are now commercially available.

In addition to system characteristics, the work to date reflects individual department (3, 8), community hospital (1, 2, 5, 6), and university teaching hospital settings (4, 7, 9). Except to the degree that the institutional setting influences the information handling needs, the type of cost evaluation conducted and the specific methodologies employed are determined more by the objectives for implementing automation and the purpose for and perspective of the evaluation than by the characteristics of the specific system or hospital setting. Therefore, this review of the studies has been oriented toward specific methodological issues and the generic approaches to analyzing cost impacts found in one or more of the evaluation studies cited.

Practical considerations

All work on AHIS cost impacts is limited by the resources available for the study. Therefore, most studies are focused on the major impacts for which sufficient data can be obtained.

Methodological issues in evaluating AHIS costs

Estimating cost impacts of labor savings

Hospital information handling is very labor-intensive. Clerical functions have been estimated to consume 25% of hospital staff time and as much as 18% of nursing staff time. Therefore, labor savings, achieved through the reduction of clerical workload, are a major economic rationale for automating information handling. A hospital realizes direct cost savings, however, only when the savings in time devoted to clerical work are reflected in labor force reductions. Therefore there are two aspects to the cost impacts of labor savings:

(1) Workload reduction and/or redistribution (time saved) and

(2) Labor force reduction (personnel eliminated) and consequent payroll reduction.

Most of the studies done to date have considered labor savings, and savings of nursing labor have been the largest single cost reductions identified (or predicted) in most of these.

Four different techniques have been employed for estimating workload changes:

(1) task analysis (2, 4, 8, 10)—which considers time savings in individual tasks by use of industrial engineering techniques, such as Methods Time Measurement;

(2) job content analysis (5)—that estimates time savings for jobs substantially changed;

(3) work sampling (6)—which involves observation of actual time devoted to tasks; and

(4) trend analysis (10)—which is based on historical trends in productivity and anticipated changes.

In task analysis, individual work activities that will be affected by automation are identified, e.g., filling out an X-ray requisition, telephoning for a laboratory result. Then the time spent in the activity in the manual system is measured. The time spent in

the activity with automation is measured, (in a retrospective study) or predicted (in a prospective evaluation). This information is combined with information on the volume of activity and the salary of personnel performing the task in order to calculate labor savings. Table 2 illustrates this technique. Task analysis provides a complete inventory of potential impacts but translating time savings in specific tasks to reductions in payroll is difficult, as will be discussed later.

Job content analysis overcomes some of the problems of task analysis since it focuses on the employee, rather than the task. The steps in this process include identifying jobs that will be performed differently with AHIS, estimating (or measuring) the time that will be saved, and redefining (combining) jobs to realize the savings. Table 3 shows the results of a job content analysis.

Job content analysis is usually performed in collaboration with the supervisor of a department, since thorough knowledge of the area is required, and since supervisors must agree to implement any changes. Job content analysis is less time-consuming to perform than task analysis and results are easier to translate into realistic staff reductions. It may also be less accurate since judgements of time savings are used and there may be incentives to inflate or underestimate savings.

Work sampling (also referred to as activity sampling) can also be used to estimate labor savings. In this case the work performed by individuals is documented by measuring periodically the activity of personnel in a unit over an extended period. The data are used to describe how individuals or categories of staff spend their time. Then the activities affected by AHIS can be identified and the potential labor savings can be estimated (in predictive studies) or measured (in retrospective studies). Since work sampling provides information on how time is allocated to work activities, it can be used to determine how activities have changed (use of freed-up time) and how much "downtime" exists in manual and automated systems, etc. Table 4 provides results of work sampling of information handling activities in a surgical intensive care unit.

Work sampling is especially useful in analyzing labor impacts in nursing units. Nursing staff perform many information handling tasks in conjunction with other patient care activities but may not devote large blocks of time solely to information handling. Sometimes information handling and patient care tasks are performed simultaneously. Therefore, changes in nursing staff activities can be best captured and quantified by direct ob-

Table 2. Example of task analysis for admitting department

Function	*Job title*	*Time savings (min. per unit)*	*Volume (units per day)*	*FTE reduction*	*Basis for time savings*
Process Pre-Admission	Admitting Clerk	8.0	26	0.6	Preparation of Admission Record and typing and filing of admission form replaced by direct type-in of reservation/pre-admission data on VMT from phone call or mailed-in Pre-admit form. Case Card File eliminated. Simplifies entry and release of pre-admit orders and screening.
Bed Assignment for Daily Admissions	Dept. Head (60%)	4.0	31	0.4	Eliminates Maintenance of Bed Availability records and preparation of Bed Cards. Replaced by scheduled admit list and bed assignment sheet.
	Assistant Dept. Head	4.0	21	0.2	
	Admitting Clerk	1.0	51	0.2	
Sub-Total				0.8	
Process Emergency Admission	Admitting Clerk	5.0	17	0.3	Eliminates transcription of Admission data to Admission Form. Faster bed assignments. Eliminates phone calls from Emergency and checks of Case Card File.
Process Scheduled and Urgent Admission	Admitting Clerk	5.0	52	0.8	Automatic assignment of new control numbers. MIS provides on-line case # file. Eliminates distribution of Admit Records. Eliminates distribution of patient information to Information Desk and Switchboard and other patient lists.

Process Transfer	Dept. Head (60%)	3.0	10	0.1	Eliminates preparation and distribution of Transfer Slip. Eliminates making new bed assignment on board.
	Assistant Dept. Head	3.0	7	0.1	
Sub-Total				0.2	
Process Discharge	Admitting Clerk	3.0	52	0.4	Eliminates preparation of Discharge Notice and distribution of same.
Preparation of Admission Lists of Daily Admissions, Transfers, Discharges	Dept. Head or Asst.	15.0	1	0.1	Preparation eliminated. Computer automatically prints list.
DEPARTMENT TOTAL	Dept. Head			0.5	
	Asst. Dept. Head			0.4	
	Admitting Clerk			2.3	
				3.2	

Source: Technicon Medical Information Systems Corp., *Cost-Benefit Analysis of the Technicon Medical Information System (MIS) for Unnamed Hospital)* December 1975.

Table 3. Example of job content analysis for a radiology department

Job	Affected tasks	Saved hours per day
Technician 1.....	perform exams	0
Technician 2.....	perform exams	0
Technician 3.....	scheduling, perform exams	1
Technician 4.....	perform exams, retrieve files	3
Clerk 1.....	transcription of reports	7
Clerk 2.....	scheduling/phone	4
Clerk 3.....	phone/x-ray filing	6
Clerk 4.....	phone/scheduling/report distribution	2
Clerk 5.....	phone/requisition processing/receptionist	3

Source: Arthur D. Little, Inc.

servation (as in work sampling).

Trend analysis involves examining trends in cost variables (i.e., nursing cost/patient day) prior to AHIS with those after AHIS to identify and quantify changes. The technique is used most often in retrospective studies but can also be used prospectively if there is information available to project trends. Performing a trend analysis to estimate labor savings involves first collecting historical data on trends in labor productivity and extrapolating these trends into the future. In retrospective studies, productivity after AHIS would be plotted, in prospective studies future productivity must be estimated. Once the trends with and without the AHIS have been plotted, then the two productivity lines are compared in order to estimate labor productivity differences at different points in time. Table 5 and Figure 1 show an example of trend analysis of productivity of nursing labor on an inpatient unit.

Results from trend analysis are difficult to interpret because changes in labor cost or productivity can be the result of many causes other than changes in information handling tasks. Major influences on staff productivity may result from changes in the patient mix, the occupancy rate, regulatory and payment policies, or the addition of new services (especially intensive care services). Identifying and adjusting for these other variables to isolate the impact of an AHIS is a difficult undertaking. Furthermore, the large number of institutional variables make it impossible to generalize the results of trend analysis performed in one institution to other hospitals.

An overview of the steps involved in estimating workload and personnel reduction for each methodology is presented in Table 6, along with the advantages and disadvantages of each approach. At the present time, the most efficient approach appears

Table 4. Results of nursing staff work sampling in a surgical intensive care unit

Code	Activity	Hours per shift			Hours per patient			
		Day	Evening	Night	Day	Evening	Night	Total
11	Patient Measurements (Monitor Type)	1.4	0.8	0.5	0.2	0.1	0.1	0.4
32	Non-drug Ordering	0.8	0.4	1.1	0.1	0.1	0.1	0.3
33	Drug Recording	0.1	0	0.1	—	—	—	—
34	Non-drug Recording	4.9	3.0	4.4	0.6	0.3	0.6	1.5
45	Review Patient Records	3.9	3.4	3.3	0.4	0.4	0.4	1.2
52	Communication with Nurses	9.6	4.1	3.6	1.1	0.5	0.5	2.1
53	Communication with Doctors	3.2	1.6	3.1	0.4	0.2	0.4	1.0
71	Research	—	—	—	—	—	—	—
72	Teaching or Education	4.25	0.3	0.4	0.5	—	0.1	0.6
	Total	28.2	13.6	16.5	3.2	1.5	2.1	6.8

Source: Arthur D. Little, Inc., *A Review of the Medlab System in the Surgical Intensive Care Unit at the Massachusetts General Hospital, Appendix A.* Report to the National Center for Health Services Research and Development, Contract HSM 110-70-406, March 1973.

Table 5. Example of prediction of avoided increases in nursing costs

Inpatient service	*Year ending*				
Medical/surgical	*Dec. 1977*	*Dec. 1978*	*Dec. 1979*	*Dec. 1980*	*Dec. 1981*
Nursing hours per patient day:					
—without MIS	7.69	7.90	8.10	8.31	8.51
—with MIS	7.60	7.60	7.60	7.60	7.60
—increase avoidance with MIS	0.09	0.30	0.51	0.71	0.91
Med/Surg. patient days per month	9,698	9,485	9,272	9,059	8,846
Med/Surg. nursing hours increase avoidance with MIS	873	2,846	4,729	6,432	8,050
Full Time Equivalents	5.04	16.42	27.28	37.11	46.45
Average salary, including fringe	$1,333	$1,432	$1,538	$1,652	$1,774
Med/Surg. cost avoidance	$6,718	$23,513	$41,969	$61,305	$82,404
Obstetrics					
Nursing hours per patient day:					
—without MIS	8.80	9.72	10.64	11.56	12.48
—with MIS	8.42	8.42	8.42	8.42	8.42
—increase avoidance with MIS	0.38	1.30	2.22	3.14	4.06
Obstetrics patient days per month	730	699	669	638	608
Obstetrics nursing hours increase avoidance with MIS	277	827	1,485	2,003	2,469
Full Time Equivalents	1.60	4.77	8.57	11.55	14.25
Average salary, including fringe	$1,333	$1,432	$1,538	$1,652	$1,774
Obstetrics cost avoidance	$2,133	$6,834	$13,179	$19,094	$25,274

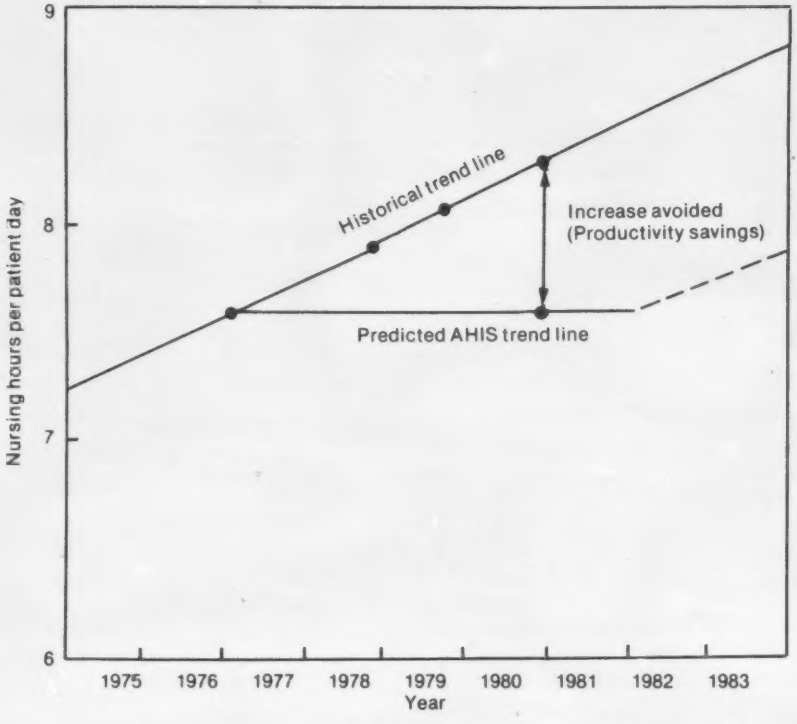
Newborn	*Dec. 1977*	*Dec. 1978*	*Dec. 1979*	*Dec. 1980*	*Dec. 1981*
Nursing hours per patient day:					
—without MIS	9.30	9.73	10.48	11.23	11.98
—with MIS	8.98	8.98	8.98	8.98	8.98
—increase avoidance with MIS	0.32	1.07	1.82	2.57	3.32
Newborn patient days per month	608	578	578	547	517
Newborn nursing hours increase avoidance with MIS	195	618	1,052	1,406	1,716
Full Time Equivalents	1.12	3.56	6.07	8.11	9.90
Average salary, including fringe	$1,333	$1,432	$1,538	$1,652	$1,774
Newborn cost avoidance	$1,493	$5,110	$9.336	$13,401	$17,570
Summary - all services					
Full Time Equivalents					
—Medical/Surgical	5.04	16.42	27.28	37.11	46.45
—Obstetrics	1.60	4.77	8.57	11.55	14.25
—Newborn	1.12	2.68	6.07	8.11	9.90
—Total	7.76	23.87	41.92	56.77	70.60
Cost Avoidance					
—Medical/Surgical	$6,718	$23,513	$41,969	$61,305	$82,404
—Obstetrics	2,133	6,834	13,179	19,094	25,274
—Newborn	1,493	5,110	9,336	13,401	17,570
—Total	$10,344	$35,457	$64,484	$93,800	$125,248

Source: Technicon Medical Information Systems Corp., *Cost-Benefit Analysis of the Technicon Medical Information System (MIS) for Unnamed Hospital)* December 1975.

to be using job content analysis for non-nursing labor and work sampling for nursing labor.

Several questions must be answered before the potential workload reductions can be translated into realistic estimates of labor force reductions:

- What is the minimum staffing in each area that will be required independent of the clerical workload?
- Can time savings within a unit be realized across shifts?
- Can time savings within a unit be summed across labor categories?
- Can time savings be realized across nursing wards?
- Can savings of partial FTEs be realized?



Note: Trend lines are not based on actual data and are presented only to illustrate the use of trend analysis to estimate cost avoidance.

FIGURE 1. Sample trend analysis of nursing productivity on medical/surgical service for use in study of labor cost avoidance

Table 6. Overview of methodologies for predicting cost impacts of labor savings

	Task analysis	*Job content analysis*	*Work sampling*	*Trend analysis*
Estimate Workload Reduction	1. Identify information handling tasks. 2. Measure time spent to perform task by each labor category. 3. Estimate time required to perform task with AHIS and the labor category involved. 4. Calculate time difference for each task by labor category. 5. Document volume of tasks. 6. Multiply time difference for task by volume. 7. Convert time savings for task into FTE labor categories. 8. Sum FTEs for all tasks.	1. Identify job positions with workload to be changed substantially. 2. Estimate amount of time devoted to the affected tasks. 3. Estimate time savings by job category.	1. Measure staff time spent in performing tasks by activity sampling. 2. Predict time required for information handling tasks after implementation of AHIS. 3. Estimate time savings by job category.	1. Collect historical data on trends in labor productivity. 2. Plot trends and extrapolate into future. 3. Estimate productivity change after implementation of AHIS. 4. Plot trend line for post-AHIS productivity. 5. Calculate productivity difference between historical trend line and AHIS trend line at specific times in the future.
Estimate Labor Savings	9. Identify staff reductions. 10. Calculate payroll savings for eliminated jobs.	4. Realign jobs and alter staffing patterns for adjusted workload. 5. Calculate payroll savings for eliminated jobs.	4. Correlate time savings with staffing changes. 5. Calculate payroll savings for eliminated jobs.	6. Calculate payroll difference (cost avoidance) based on productivity savings.
Advantage:	Complete inventory of potential impacts.	Less costly and results easier to translate into realized labor savings	Provides "snapshot" of how time is spent before and after automation	Easy to apply
Disadvantage:	Costly and time consuming	Less accurate	Costly and time consuming	Lack of productivity standards for various labor categories make accurate labor saving predicting difficult.

Some of the published work to date on AHIS cost impacts has been based on unrealistic assumptions about realizing the potential labor savings and this has lead to overstated cost impacts.

To illustrate the importance of these questions, consider the data presented in Table 7. Here savings in minutes of time per day have been converted to FTEs by dividing by production work minutes per day (adjusted for vacations, holidays and illness) and summed for each nursing station, shift and job category. A quite conservative estimate will be obtained if one rounds savings down to the nearest whole FTE for each labor category within each shift and unit. This would mean that in two wards no savings would be predicted, and only one or two staff reductions would be counted in the remaining areas. A total of 17 saved FTEs would be predicted. Alternatively, if one assumes that all partial FTE savings can be realized, then these projections could be converted directly into labor force savings of 47.4 FTEs. It is easy to see that the treatment of partial FTEs is critical to the resulting estimate of realizable labor savings.

The real savings to be realized from the example in Table 7 probably lie somewhere between 17 and 47.4 FTEs. For example, if one were to take a conservative approach to converting time savings to FTE staff reductions, one might:

- Assume savings can only be summed within one department.
- Assume transfer of tasks from lower to higher level staff to realize time savings: RN's taking on functions previously performed by aides or clerks, technicians replacing clerks in ancillary departments.
- For nursing departments assume small amounts of time savings (less than 0.2 FTEs) can be transferred between shifts.
- Assume that 50% of the time savings of 0.5 FTE or more can be realized by use of part-time staff. (In some cases savings won't be possible because of core staffing requirements, e.g., at least one ward clerk must be on duty or answer phone).
- Round remaining partial FTEs down to next lowest whole FTE.

When these assumptions are applied to the workload savings estimates from El Camino Hospital, the resulting estimate of realizable labor saving for the nursing units in Table 7 is 38 FTEs (Arthur D. Little, Inc., estimate).

Table 7. Example of potential labor savings for nursing services

Estimated labor savings (FTE)

Station	Day shift		Evening shift		Night shift	
	Ward Clerk	RN/LVN/ Aide	Ward Clerk	RN/LVN/ Aide	RN/LVN/ Aide	Total
1 South	.46	.78	.23	.66	.51	2.64
Maternity	1.23	1.67	.40	1.00	1.66	5.96
2 East	1.04	1.37	.42	.93	.82	4.58
2 West	1.00	1.32	.44	.85	.81	4.42
Pediatrics	.80	.88	.33	.60	.76	3.37
3 West	.95	1.47	.40	1.00	.84	4.66
4 West	1.01	1.31	.44	.91	.88	4.55
5 East	1.20	1.66	.53	1.05	.94	5.38
5 West	.92	1.20	.43	.77	.76	4.08
6 East	.90	1.23	.38	.81	.73	4.05
6 West	.81	1.11	.34	.76	.69	3.71
						47.40

Source: Gall, J. E., *et al. Demonstration and Evaluation of a Total Hospital Information System*. National Center for Health Services Research. NTIS PB 262106. 1975.

Realizing labor savings

The automation of information handling and communication through an AHIS offers many potential labor-saving benefits to the hospital. Eliminating entire functions (e.g., preparation of billing charge slips) often means that easily identified jobs can be eliminated (e.g., billing clerks). However, the bulk of the clerical labor savings are more likely to occur piecemeal across many departments, shifts, and labor categories.

Turning these time savings into labor force reductions requires a deliberate effort to reorganize services by undertaking work methods improvement, redistributing job titles, and redefining job roles among various labor categories. Without an active benefits realization effort, activity displacement may result in increased idle time for hospital staff rather than in payroll savings.

Also, labor benefits following implementation of an AHIS are only achieved slowly as the staff learns to use the system and take advantage of its labor-saving features. Actual savings are realized in increments and maximum savings are not likely to result for several years.

Choosing an economic analysis methodology.

In decisionmaking about acquiring an AHIS, costs and benefits (cost savings) should be evaluated as they would be for any major investment. Typically, a hospital first incurs a large initial capital cost and only realizes economic benefits incrementally in later

years. Present value methodology applied to a life-cycle cost analysis provides a useful analytical framework for valuing the anticipated stream of economic savings (net benefits) over the useful lifetime of the system. It employs discounting procedures to reflect the fact that benefits received in future years are worth less than the same amount of money today. Thus, it permits a comparison of expected future benefits and present expenditures that incorporates the time value of money.

Selecting the appropriate discount rate is one problem in applying the present value technique. Discount rates used range from 2.5% to 12% – the larger the discount rate, the lower the present value of future moneys. Because there is no consensus among economists as to which rate to use, several are often used and the results compared. Life cycle analysis requires an assumption about the useful lifetime of the AHIS. Although computer systems such as AHIS are continually maintained and enhanced, at some point the requirements on the system and the availability of more cost-effective systems make them obsolete. A system life cycle of eight years has been used in most AHIS cost evaluations and seems to strike a reasonable balance between the timephasing of new computer generations and the investment required to implement a new system.

Calculating system cost

Documentation of system costs appears at first to be a simple, straight-forward task. Indeed most previous studies have devoted little attention to this area, using only system purchase price and installation cost as measures of system costs. Actually total system cost involves a large number of components:

- manpower required for selection and planning activities;
- initial hardware cost;
- initial software cost;
- facilities renovation to accommodate the system;
- cost of money to finance the installation;
- installation costs (vendor charges and personnel supplied by hospital);
- hardware and software modifications or additions (by vendor or in-house) both during implementation and subsequently over the system's lifetime;

- supervision of system installation and start-up;
- training of staff in AHIS use and time spent by users in learning the sytem; and
- support personnel to manage the system and interface with users;
- cost of special supplies, support services, overhead, and other operational expenses.

Thus a careful accounting of system costs must include expenditures for services and equipment obtained from a system or service vendor and the investment in in-house personnel required to install and utilize the system. When system costs are being compared with labor savings, the cost of a benefits realization effort to bring about the necessary operational changes needs to be included as well.

Using regression analysis

One approach to studying impacts of AHIS implementation retrospectively is regression analysis. In its simplest form, the statistical technique uses time and trend lines for various cost or productivity indicators (such as nursing hours per patient day). These indicators are calculated from historical data points, which are used to extrapolate what the indicator would have been without AHIS. The extrapolated data are then compared with actual values for the comparable indicators after the AHIS is in use. More complicated forms of regressions include comparison of trends across comparable hospitals and multiple regression analysis, which attempts to include in the equation the many independent variables, in addition to implementation of an AHIS, that may influence the dependent variable of interest. Simple trend analysis does not account for confounding factors such as implementation of utilization review or change in case mix of the patient population; multiple regression, which can handle these factors, is more difficult to apply.

A number of factors make regression analysis difficult to use:

- In multiple regressions, measures of important independent variables may not be available.
- The results of regression analysis may be biased by variables that are unknown or omitted for practical reasons. Variables must be selected carefully and interactions understood or the results may be misleading.

- Seasonal effects, which can be important, require several years of data both before and after AHIS implementation, in order to control for their influence on the dependent variable(s) examined.

- Although comparisons across hospitals can help control for the effects of outside influences, inter-hospital comparisons are hampered by the difficulties of measuring all the factors and inherent differences between hospitals.

Nevertheless, when applied carefully, regression analysis can be useful in evaluating the impact of AHIS on hospital costs, and in validating the results of industrial engineering studies. Regression analysis is used in some previous studies (1, 2). However, regression analysis can be costly in terms of its special data collection requirements, and because of the difficulty in understanding the underlying relationships between variables, it probably should not be the only analytical technique used.

Including quality of care benefits

The motivation for implementing an AHIS is rarely only cost savings. Improved information handling can result in benefits to patient care that are difficult to translate into economic terms. Benefits such as improved response times for communications and increased availability of nursing staff time for direct patient care have been documented at all sites where they have been studied (2, 6). There are indications that AHIS may shorten length of stay by shortening turnaround time for ancillary services (1). The cost savings implications of changes such as these have not yet been tied conclusively to automated information handling.

Comparison of three predictions of AHIS cost impacts

Three predictive cost studies of comprehensive AHIS are available for community hospitals of similar size (400-600 beds): the study by Gall *et al.* at El Camino (2), the Technicon study at an unidentified hospital (10), and the study for Fairfax Hospital (5). These were compared in order to examine the consistency of the results and to determine how differing assumptions affect the predictions of cost impacts.

A comparison of predicted total annual and per-patient day savings is presented in Table 8. In order to make the study results more comparable, the figures shown do not include estimates of savings based upon unique and less accepted assumptions. The estimated savings due to "work methods improvement" at El Camino were expected to result from an intensive program to realize nursing labor savings. Because these savings are not directly attributable to the AHIS alone, they are not included. The "nursing cost avoidance" estimates in the Technicon study based upon trend analysis and the hypothesized stabilization of nursing productivity following implementation of the AHIS are also not shown. Note that the Fairfax study did not include nursing savings because the system could be cost justified on the basis of savings in non-nursing labor and the authors believed that realizing nursing labor savings would be difficult.

Table 9 presents the estimates cost savings in the ancillary and support areas, by individual departments for the three hospitals. As indicated, not all three hospitals examined savings in all areas.

Table 8. Comparison of predicted annual and per patient day savings from three predictive studies of AHIS cost impacts

Type of savings	Savings: Annual — El Camino ('75-'79)	Annual — Technicon ('77-'81)	Annual — Fairfax ('80-'81)	Per patient day — El Camino	Per patient day — Technicon	Per patient day — Fairfax
Nursing personnel	$ 807,000 [2]	$ 604,999 [3]	$ NA	$ 6.56	$ 4.84	$ NA
Non-nursing personnel	209,616	350,765	533,107	1.71	2.81	2.80
Total labor	$1,016,616	$ 955,764	$533,107	8.27	7.65	
Equipment	$ 7,044	$ 13,788	$ 50,848	.06	.11	.27
Forms	57,732	75,216	20,800	.47	.61	.11
Materials and other	13,380	—	92,192	.11	—	.48
Total non-labor	$ 78,156	$ 89,004	$163,840	.64	.72	.86
TOTAL	$1,094,772	$1,044,768	$696,947 [1]	$ 8.90	$ 8.36	$ 3.66 [1]

[1] Does not include nursing savings.
[2] Work Method Improvement not included.
[3] "Cost Avoidance" not included.

Table 9. Estimated ancillary and support cost savings from three predictive studies of AHIS costs

Area	Total annual savings					
	El Camino	%	Technicon	%	Fairfax	%
Inpatient registration/admission	$ 62,142	35	$ 46,476	15.5	$ 39,500	6
Laboratory	—	—	46,476	15.5	139,524	20
Medical records	—	—	30,984	10	96,530	14
Outpatient/ER/clinics	—	—	—	—	90,700	13
Pharmacy	37,809	21	117,223	39	199,145	29
X-Ray	12,734	7	17,342	6	79,248	12
Utilization review	—	—	—	—	37,900	6
Business office/accounting	53,832	31	43,423	14	—	—
Central service	10,930	6	—	—	—	—
TOTAL	$177,445	100	$301,924	100	$682,547	100

After eliminating the savings based on questionable assumptions, the estimated cost impacts for the hospitals considered in the studies, are approximately $1 million per year, equivalent to about $9 per patient day. These impacts would increase with time, principally because of inflation (estimated at 7-8% per year). Since personnel costs escalate faster than system costs (which tend to be more fixed by contract), the comparison of savings versus AHIS costs would also tend to improve over time. These projected savings have to be compared with system costs in order to estimate the net cost impacts of AHIS implementation.

The majority of the predicted cost impacts (over 90%) come from potential savings in personnel. Such savings amount to approximately $8 per patient day. Of these savings, the majority (60-80%) is attributed to reduction of nursing personnel requirements. As discussed previously in this report, achievement of this reduction is dependent upon a significant effort directed to achieve the savings through reorganization of nursing staff tasks and staff schedules, so that the personnel reductions do take place.

The non-personnel savings are considerably more modest, under $1 per patient day. Reduction of forms in the hospitals can contribute about $.50 of this reduction.

The ancillary department with the consistently greatest savings was pharmacy, which accounted for between 21-39% of estimated ancillary savings. The next most important department was inpatient registration/admitting, which accounted for between 6% and 35% of ancillary savings. These were followed next by laboratory with 15% and 20% of savings* and radiology, with 6% and 12% of the savings.

The savings shown in Tables 8 and 9 should be considered indicative of order-of-magnitude estimates only, since they apply to different time periods, and were based upon somewhat different assumptions with regard to personnel and non-personnel inflation rates, personnel fringe benefit rates, etc.

* For those hospitals where these impacts were quantified.

Analyzing revenue implications

Published analyses of AHIS cost impacts have varied greatly in their treatment of the revenue implications of an AHIS. In the Fairfax Hospital study (5), reduction in receivables was treated as a one-time cost saving. One study did not include the effects of increased revenue capture because of the fact that payers reimbursing the hospital on a cost basis would adjust rates downward to counteract any increase in the volume of charges (1). At the other extreme, the analysis of the AHIS in the Radiology Department at the Hospital of the University of Pennsylvania counts as a cost benefit the full value of lost charges captured as a result of automation (estimated at 2.5% of total department charges) (3). This same method was used in the study at Santa Monica Hospital (4). Others, such as Schmitz in his evaluation of the AHIS at Deaconess Hospital in Saint Louis (9), recognize that the evaluation of revenue implications is complex, and must consider reimbursement patterns and patient mix.

An AHIS can have two general types of impacts on hospital revenue. If the elapsed time between service delivery and billing is reduced, the hospital may be able to reduce the amount of a working capital loan (and hence the interest owed) or receive a one-time increase in available cash. Either way, reduction in receivables is a tangible financial benefit to the hospital and the health care system.

The second type of revenue impact is the capture of revenue previously lost to the hospital because of inaccurate or incomplete information about services delivered to patients. More accurate billing for services, however, does not affect the costs of care. Since the costs are incurred when the services are delivered, these costs will exist whether or not the services are billed. More accurate billing through automated charge capture may influence how costs are paid for and who pays for them and it may also affect the hospital's revenue; but it does not reduce the costs of care delivery.

Therefore, cost savings and revenue capture are two separate impacts of an AHIS. The inclusion of revenue capture as a cost savings in studies done in the past has led to overstated cost impacts. Revenue implications of an AHIS may be of interest to a hospital administrator. However, analysis of revenue impacts should be conducted as a separate study, not as part of a cost impact analysis.

Any evaluation of revenue implications must recognize that there are at least three sets of variables that govern the revenue impacts at a particular hospital:

- The type of system being evaluated and the measure of revenue capture used in the analysis. For example, revenues to departments within hospitals are often analyzed differently than revenues to the hospital.
- The proportions of patients treated in the institution who pay charges themselves or are covered by insurance plans that pay hospital charges, and the proportion of patients covered by insurance plans that reimburse the hospital on some cost-related basis.
- The formulas used to determine hospital payment by each payer using a cost-related rate, and any overall limitations that are imposed on the hospital's budget or charges by state or Federal regulatory agencies.

In order to understand any particular analysis of AHIS-related revenue increases, it is necessary to understand each of these sets of variables and their effect on the calculation of revenues.

Conclusions and recommendations

Conclusions

- Few rigorous studies have been conducted of cost impacts of implementation of automated hospital information systems.
- Most of the work done in this area in the past has involved predicting cost impacts. Somewhat overstated cost savings (largely the result of unrealistic labor savings and inclusion of revenue impacts) and understated system costs may have produced unrealistic estimates of the net cost impacts of AHIS.
- Little work has been done on validating the results of predictive methodologies. Therefore, there is very little documentation of actual impacts of an AHIS on the productivity of hospital staff or on overall changes to guide the conduct of cost assessments.
- Through improvements in information flow, an AHIS offers benefits to the quality of service delivery, and these are usually major motivations for a hospital to implement a system. More work needs to be done exploring the cost implications of improvments in the quality of service delivery, such as improved turnaround time for test results reporting and decreased loss of information.
- Revenue recovery from charge capture is not a measure of changes in the costs of operating a hospital and, therefore, should not be counted amount the cost impacts.
- Cost studies have been conducted for different hospital settings and system configurations. The specific methodologies employed are generally applicable, however, to any setting or system type. The purpose in undertaking the cost study determines the approach that is used.

Recommendations concerning approach to AHIS cost evaluation

Until the results of predictive studies are validated, no single methodology for predicting AHIS cost impacts can be totally endorsed. The approach recommended, however, builds upon the work done in the past and avoids major pitfalls. The approach involves several steps.

(1) *Defining system goals and objectives*
This will establish the priority given to cost savings relative to other motivations for automating and identify the parameters of the cost study.

(2) *Identifying major cost impacts*
This is necessary not only because analyzing all impacts is very time-consuming and costly, but also because departments performing the greatest volume of clerical information handling are the most likely to experience actual cost reductions.

(3) *Valuing labor impacts*
For labor savings, the most realistic approach is to estimate workload reductions by job content analysis (for non-nursing labor) and work sampling (for nursing staff) and then to develop new staffing plans incorporating work force reductions in consultation with shift supervisors and department managers.

(4) *Checking predictions*
Ideally predictions should be compared with actual experience with similar installations at other hospitals. Until this type of information becomes available, predictions can be compared with the results of previous predictive studies.

(5) *Identifying costs*
Care has to be taken to identify all components of costs and to develop realistic estimates of the total costs of the system.

(6) *Establishing time frame for stream of costs and cost savings*
Life cycle analysis and present value methodology provide a realistic analytical framework for a predictive AHIS cost study.

(7) *Documenting actual system costs*
Because of the uncertainties regarding the accuracy of predicted cost impacts, any predictive study should be accompanied by a commitment to monitor actual cost impacts after the system is implemented.

Recommended directions for future research

More research is needed to help decisionmakers – hospitals, health planners, and regulators – evaluate the cost impacts of AHIS. Since decisionmakers are primarily concerned with predicting savings prior to an investment in AHIS, it is important to validate whether the techniques being used to predict savings are accurate.

Many different types of AHIS are available and they vary greatly in terms of scope, design, and cost. Information about the costs and benefits of individual system applications, such as medication ordering and radiology scheduling, would be useful for comparing systems with different features and for designing more cost-effective systems.

Optimal use of an AHIS and realization of all potential benefits requires a directed effort on the part of the users. Although some work has been done on developing a benefits realization program for certain AHIS benefits (2), the expansion and transfer of this type of program from one institution to another has never been studied. Research on incentives is also needed to ensure that the benefits of future AHIS implementations are maximized. This could involve disseminating information about the cost impacts of AHIS and the factors that determine savings, providing technical assistance on conducting benefits realization programs, and considering changes in reimbursement policy that would offer hospitals more immediate financial incentives to realize AHIS benefits.

Before hospitals can incorporate the experience at other sites into their decisionmaking about AHIS, the transferability of that experience has to be considered. Ideally, guidelines should be available concerning the range of cost impacts of different automated systems and the factors that determine the magnitude of these at each installation.

Most AHIS, and all comprehensive AHIS, are implemented primarily to improve patient care by improving the communication of information. Therefore, techniques for examining the cost impacts of these improvements in information flow would be extremely valuable in completely assessing the cost impacts of automation.

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Research Summaries

The *Research Summary Series* provides rapid access to significant results of NCHSR supported research projects. The series presents executive summaries prepared by the investigators. Specific findings are highlighted in a more concise form than in the final report. The *Research Summary Series* is intended for health services administrators, planners, and other research users who require recent findings relevant to immediate programs in health services.

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(HRA) 77-3176 Quality of Medical Care Assessment Using Outcome Measures (PB 272 455)

(HRA) 77-3183 Recent Studies in Health Services Research, Vol. II (CY 1976) (PB 279 198)

(PHS) 78-3187 Criterion Measures of Nursing Care Quality (PB 287 449)

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(PHS) 81-3298 Regulating Hospital Capital Investment: The Experience in Massachusetts

Research Reports

The *Research Report Series* provides significant research reports in their entirety upon the completion of the project. Research Reports are developed by the principal investigators who conducted the research, and are directed to selected users of health services research as part of a continuing NCHSR effort to expedite the dissemination of new knowledge resulting from its project support.

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(HRA) 77-3159 An Analysis of the Southern California Arbitration Project, January 1966 through June 1975 (HRP 0012466)

(HRA) 77-3165 Statutory Provisions for Binding Arbitration of Medical Malpractice Cases (PB 264 409, available NTIS only)

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(PHS) 78-3219 Needed Research in the Assessment and Monitoring of the Quality of Medical Care (PB 288 826)

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(PHS) 81-3272 Estimated Economic Costs of Selected Medical Events Known or Suspected to be Related to Administration of Common Vaccines

(PHS) 80-3279 Health Care Surveys Using Diaries

(PHS) 81-3295 A Social and Economic Analysis of Professional Regulation in Optometry

(PHS) 81-3300 Hispanic Health Services Research — A Preliminary Bibliography
(PHS) 81-3303 Health Planning Review of Medical Information Systems

Research Proceedings

The *Research Proceedings Series* extends the availability of new research announced at key conferences, symposia and seminars sponsored or supported by NCHSR. In addition to papers presented, publications in this series include discussions and responses whenever possible. The series is intended to help meet the information needs of health services providers and others who require direct access to concepts and ideas evolving from the exchange of research results.

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(HRA) 77-3181 NCHSR Research Conference Report on Consumer Self-Care in Health (PB 273 811)
(HRA) 77-3186 International Conference on Drug and Pharmaceutical Services Reimbursement (PB 271 386)
(PHS) 78-3195 Emergency Medical Services: Research Methodology (PB 279 096)
(PHS) 78-3207 Health Survey Research Methods, Second Biennial Conference (PB 293 492)
(PHS) 78-3208 Drug Coverage Under National Health Insurance (PB 293 468)
(PHS) 79-3209 Health Services Research in Puerto Rico (PB 292 326)
(PHS) 80-3215 Cost Accounting for Pharmaceutical Services (PB 80-157 936)
(PHS) 79-3216 Medical Technology: The Culprit Behind Health Care Costs? (PB 299 408)
(PHS) 79-3225-1 Emergency Medical Services Research Methodology: Workshop 1 (PB 294 048)
(PHS) 79-3225-2 Emergency Medical Services Research Methodology: Workshop 2 (PB 80-142 292)
(PHS) 78-3227 Effects of the Payment Mechanism on the Health Care Delivery System (PB 291 231)
(PHS) 79-3228 A National Conference on Health Policy, Planning, and Financing the Future of Health Care for Blacks in America (PB 292 559)
(PHS) 79-3233 Emergency Medical Services Systems as a Health Services Research Setting (PB 297 102)
(PHS) 79-3254 Medical Technology (PB 80-149 511)
(PHS) 79-3256 Sharing Health Care Costs (PB 80 162 795)
(PHS) 79-3257 Health Facility Reuse, Retrofit, and Reconfiguration (PB 80-142 383)
(PHS) 81-3268 Health Survey Research Methods, 1979
(PHS) 80-3288 Hispanic Health Services Research

Research Management

The *Research Management Series* describes programmatic rather than technical aspects of the NCHSR research effort. Information is presented on the NCHSR goals, research objectives, and priorities; in addition, this

series contains lists of grants and contracts, and administrative information on funding. Publications in this series are intended to bring basic information on NCHSR and its programs to research planners, administrators, and others who are involved with the allocation of research resources.

(PHS) 79-3220 Emergency Medical Services Systems Research Projects, 1978 (PB 292 558)
(PHS) 80-3271 Emergency Medical Services Systems Research Projects Abstracts, 1979
(PHS) 81-3287 Computer Tapes Available from 20 Health Services Research Projects
(PHS) 81-3304 Emergency Medical Services Research Project Abstracts, 1980
(PHS) 81-3307 Summary of Grants and Contracts Active on September 30,1978

NHCES

The *National Health Care Expenditures Study Series* presents information and analyses on critical national health policy issues. Basic data were obtained from the National Medical Care Expenditure Survey, a statistical picture of how health services are used and paid for. Data Previews give preliminary estimates of key measures.

(PHS) 80-3276 Data Preview 1: Who are the Uninsured?
(PHS) 80-3275 Data Preview 2: Charges and Sources of Payment for Dental Visits with Separate Charges
(PHS) 80-3278 Data Preview 3: Who Initiates Visits to Physicians' Offices?
(PHS) 80-3290 Data Preview 4: Health Insurance Coverage of Veterans
(PHS) 80-3291 Data Preview 5: Charges and Sources of Payment for Visits to Physician Offices
(PHS) 80-3296 Data Preview 6: Waiting Times in Different Medical Settings: Appointment and Office Waits

Policy Research

The *Policy Research Series* describes findings from the research program that have major significance for policy issues of the moment. These papers are prepared by members of the staff of NCHSR or by independent investigators. The series is intended specifically to inform those in the public and private sectors who must consider, design, and implement policies affecting the delivery of health services.

(HRA) 77-3182 Controlling the Cost of Health Care (PB 266 885)

Program Solicitations

(PHS) 81-3292 Grants for Research on Health Promotion and Disease Prevention

(PHS) 81-3293 Extramural Associates Program, 1981
(PHS) 81-3299 Grants for Dissertation Support, 1981

NCHSR Fact Sheets

NCHSR Fact Sheets provide concise information on NCHSR's organization and mission, as well as on key problems in health services and research directed toward meeting health care needs.

National Center for Health Services Research (English)
National Center for Health Services Research (Spanish)
National Center for Health Services Research (Chinese)
NCHSR Research Focus, 1981 - 1982
Catastrophic Illness
Health Care and the Disadvantaged
Hospital Cost and Utilization Project
Long-term Care
Manpower
Maternal and Child Health Care
National Health Care Expenditures Study
United Mine Workers of American Health Care Plan
Emergency Medical Services Systems
NCHSR Research Grant Application and Scientific/ Technical Merit Review Procedures
Computer Applications in Health Care